Marine Fisheries Research and Management

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2000

10 Sea cucumbers

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ABSTRACT

Sea cucumbers are a group of economically important echinoderms with a wide range of distribution in coral to mangrove habitats. Out of 200 species known from Indian seas, 75 are from shallow seas; while only a dozen of them belonging to Holothuridae and Stichopodia are large with thick body wall and hence commercially important. They occur in exploitable concentration in the Gulf of Mannar, Palk Bay, Lakshadweep and Andaman & Nicobar Islands. The paper presents family, genera and species key to identification along with the description and distribution of important species. The paper also reviews their ecology, animal association, parasites, biotoxicity, collection, handling and processing for beach-de-mer, conservation and management and hatchery and culture in Indian situation.

INTRODUCTION

Sea cucumbers belong to a group of spiny-skinned animals which also include the star fishes, sea feathers, brittle stars and the sea urchins. They are entirely marine and economically important. They occur from the supralittoral zone to the hadal zone. They occur in corals, rocky, sandy, muddy and mangrove habitats. The length ranges from a few millimetres to nearly two metres. There are over 650 species of sea cucumbers known from the various parts of the world. In the seas around India, nearly 200 species are known, of which 75 are from the shallow waters within 20 metres depth. Of these, only about a dozen are commercially important. Large sea cucumber with a thick bodywall can be used for processing. Processed sea cucumber is known as *beche-de-mer* and is a delicacy for the Chinese who use it specially on festive occasions. The technique for processing of sea cucumbers was intro-

duced into India by the Chinese more than one thousand years back. It is a cottage industry needing very little investment. The Japanese and the Koreans consume *Stichopus japonicus* in fresh condition.

Classification

Sea cucumbers belong to the class Holothuroidea. which is divided into five orders *viz.*, Dendrochirota, Aspidochirota, Elasipoda, Molpadonia and Apoda chiefly on the basis of the shape of the tentacles. In dendrochirotids., the tentacles are branched which help in the collection of planktonic food. These are evident only when the animal is fully relaxed and undisturbed. At the slightest disturbance they retract their tentacles inside the body cavity. In aspidochirotids the tentacles are peltate with a stalk ending in a bunch. The majority of the holothurians on the coral reefs belong to this order. In Molpadonia, the tentacles are digitate and the tubefeet are absent. In Apoda, the tentacles are pinnate and the tubefeet are absent as the name indicates. Many of the worm like sea cucumbers belong to this order. The elasipods are bizarre in appearance with large conical papilla, marginal rims and tail-like appendages. They inhabit the deep seas. The various families in Dendrochirota are chiefly separated based on the shape of the calcareous ring. In aspidochirotes the families are differentiated based on the shape of the body and distribution of pedicels and papillae. The species identification can be done only based on the examination of spicules embedded in the skin. General classification of sea cucumbers is given by Hyman (1955) and Nichols (1966). There is no comprehensive systematic work on the sea cucumbers of the world. The family Holothuridae was covered by Panning (1929-1935), Deichmann (1958) and Rowe (1969). Clark (1922)dealt the family Stichopodidae in some detail. The families Cucumariidae and Phyllophoridae were dealt with by Panning (1949) and Heding and Panning (1954). Clark (1907) wrote on the apodous holothurians and Heding (1928) published an account on the family Synaptidae. James (1967,1968, 1978,1981,1982,1984, 1986, 1995a, 1995b) published a number of papers on the taxonomy of sea cucumbers from the seas around India. He described a new family, two new species and reported some new records from India.

Resources

Although nearly 200 species of sea cucumbers are distributed in the seas around India, only about a dozen species are of commercial importance.

Only species belonging to the families Holothuridae and Stichopodidae are of commercial importance since they are large in size and the body wall is also thick. These are distributed in good numbers on the reefs in the Gulf of Mannar and Palk Bay and the Andaman and Nicobar Islands and the Lakshadweep. A brief account of the commercially important species found in the seas around India is given below.

Species belonging to the two families can be easily separated. Members belonging to the family Holothuridae are tubular in shape with thick and firm body wall and also the gonadal tubules are arranged in a single bunch. Members belonging to the family Stichopodidae are often massive with the body wall soft. It becomes gelatinous on exposure to air. The gonadal tubules are arranged in two bunches.

Key to the commercially important families

Body tubular, skin thick and firm, gonadal tubules in single bunch.....holothuridae

Body sometimes four sided, skin becomes gelatinous after collection, gonadal tubules in two bunches .... stichopodidae

In the family Holothuridae, three genera are commercially important. They can be separated by the following key.

Key to the genera of the family Holothuridae

1. Anal opening surrounded by five 'teeth'

   like structures.....*Actinopyga*

1'. Anal opening not surrounded by five 'teeth' like structures 2

2. Anal opening surrounded by five groups of calcareous papillae, cuvierian tubules profuse.....*Bohadschia.*

2'. Anal opening not surrounded by 'teeth' or papillae, cuvierian tubules when present not profuse.....*Holothuria*

Genus *Actinopyga* Bronn,1861

All the species belonging to this genus are of low value. They are distributed in the Gulf of Mannar, the Andaman and Nicobar Islands and the Lakshadweep. Two species are extensively processed from the Gulf of Mannar since 1989. The different species are identified based on the colour pattern and also the complexicity of spicules.

Key to the species of Actinopyga

1. Colour completely black, anal 'teeth' distinctly seen, dorsal side convex and ventral side flat.....*A.miliaris*

1. Colour uniformly brown or brown and white.....2

2. Colour brick red on the dorsal side and white on the ventral side;often found near the low water mark.....*A.mauritiana*

2'. Colour uniformly brown with wrinkles on the dorsal side with sand settling on it.....*A.echinites*

***Actinopyga miliaris* (Quoy & Gaimard)**

Common name: Blackfish

Local name: *Pal Attai* (In Tamil)

Trade name: Tuty Black

Black in colour, sometimes with a brown ventral side. Length ranges from 20-30 cm and live weight ranges from 0.5 to 2 kg.Cylindrical with five anal 'teeth' and the tubefeet arranged in three rows on the ventral side. Bodywall is 8 mm in thickness found mainly in water less than three metre depth on the reef flats. Low to medium in value. It should be processed without cutting. *A. miliaris* is commercially the most important among the species of *Actinopyga* since it is very abundant in easily accessible habitats. This species was processed for the first time from the Gulf of Mannar in 1990. During 1991, 30.7 tonnes, 1992, 31.8 tonnes and in 1993, 18.7 tonnes of processed material were exported. After three years there are clear signs

of over-exploitation. Since this was exported in large quantities from Tuticorin this species earned the trade name 'Tuty Black'.

Distribution:It is known from the Islands of the Western Indian Ocean, Mascarene Islands, East Africa and Madagascar, Red Sea, Maldives, Lakshadweep, Sri Lanka, Bay of Bengal, East Indies, North Australia, Philippines, China and Southern Japan, South Pacific Islands, Hawaiian Islands. In the seas around India it is known from the Gulf of Mannar,the Andaman and Nicobar Islands and the Lakshadweep.

***Actinopyga mauritiana* (Quoy & Gaimard)**

Common name : Surf Redfish

Body is almost cylindrical with a flat ventral side. Three rows of tubefeet are seen on the ventral side. Length ranges from 20 to 30 cm and live weight varies from 0.5 to 1 kg. Body wall is 6 mm in thickness. Colour in the living condition is brick red on the dorsal side and white on the ventral side. Found only on the outside of reefs where the surf breaks. Distribution extends upto 5 m depth. The tubefeet are firmly attached to the coral rocks to prevent the animal from being carried away by the waves. Average density is several hundred individuals per hectare. Low to medium commercial value. Processed like teatfish but the body should not be cut. There is no exploitation of this from the Gulf of Mannar now. One kg of processed material costs US$ 6.50.

Distribution: It is distributed in the Islands of the Western Indian Ocean, Mascarene Islands, East Africa and Madagascar, Red Sea, Maldives, Lakshadweep, Sri Lanka, Bay of Bengal, East Indies, North Australia, Philippines, China and Southern Japan, South Pacific Islands and Hawaiian Islands. In the seas around India, it is known from the Andaman and Nicobar Islands and the Lakshadweep. A single processed sample was collected from Ramanathapuram.

***Actinopyga echinites* (Jaeger)**

Common name : Deep-water Redfish

Local name: Paar Attai (In Tamil)

The local name refers to its habit on *Paars* (coral banks). Length ranges from 15 to 30 cm and the live weight varies from 0.5 to 1 kg. The body is wider

in the middle, tapers towards the ends and has slightly wrinkled dorsal surface. Colour is uniformly brown. Body is generally covered with a fine coating of sand. The fishing grounds are mostly off the chain of Islands in the Gulf of Mannar at a depth of 3 to 7 m. At present beyond 7 m depth diving is not carried out since the visibility is poor. The resource however seems to be good beyond 7 m. Sometimes they are found to be distributed in the intertidal region also as seen in the Andaman and Nicobar Islands and the Lakshadweep. For the first time this species was processed from the Gulf of Mannar in 1989. 16.5, 4.5 and 0.8 tonnes were processed during 1990, 1991 and 1992 respectively. It is a medium-valued species and one kg of processed material costs only US$ 4.00.

Distribution: It is known from the Islands of the Western Indian Ocean, Mascarene Islands, East Africa and Madagascar, Maldives, Lakshadweep, Sri Lanka, Bay of Bengal, East Indies, Philippines, China and southern Japan and South Pacific Islands. In the seas around India it is known from the Gulf of Mannar, the Andaman and Nicobar Islands and the Lakshadweep.

Genus *Bohadschia* Jaeger, 1833.

Massive forms with distinct anal papillae, often buried or covered with a fine coat of mud. Cuvierian tubules are profuse and because of this processing is difficult. Species belonging to this genus have moderate value. Two species are known from the seas around India.

Key to the species of *Bohadschia*

Colour black or brown with distinct 'eye' like spots all over the body.....*B.argus*.

Colour variable, yellow with fine brown spots.....*B.marmorata*.

***Bohadschia argus* Jaeger**

Common name: Leopardfish or Tigerfish

It grows to a large length of 600 mm. Colour in the living condition is brown or black. Body is cylindrical with very smooth surface. Live weight varies from 1 to 2 kg. At the slightest disturbance cuvierian tubules are thrown out. Distinct eye-spots are found all-over the body which are encircled with

light yellow and white grey colours. In the Lakshadweep however, the specimens are black in colour. The eye spots are seen in a particular angle. It occurs on coarse sand in 2 to 6 m depth. A few pieces of shell and coarse sand usually sticks to the body. This species is abundant in the Lakshadweep. It is a low valued species and one kg of processed material costs US $ 4.50.

Distribution: It is known from the Islands of the Western Indian Ocean, Lakshadweep, Sri Lanka, Andamans, East Indies, North Australia, Philippines, China and Southern Japan and South Pacific Islands. In the seas around India it is known from the Andaman and also from the Lakshadweep.

***Bohadschia marmorata* (Jaeger)**

Common name:Chalkyfish and Brown sandfish

Length of the body ranges from 150 to 350 mm, live weight ranges from 0.5 to 2 kg. Body is short and thick with the ventral surface slightly flattened. Profuse cuvierian tubules are released if the animal is disturbed. Colour is golden brown with small dark-brown dots. Common in shallow waters and buries itself in silty sands. It is distributed in depths of 2 to 15 m. It has low commercial value. Processed like teatfish but without cutting. Processing should be done with great care because the body of this species tends to fall apart after harvesting and during boiling. One kg of processed material costs US $ 2.50 to 4.00.

Distribution : It is known from the Islands of the Western Indian Ocean, East Africa and Madagascar, Lakshadweep, Sri Lanka, Andamans, East Indies, North Australia, Philippines, China and Southern Japan and South Pacific Islands. In the seas around India it is known from the Gulf of Mannar and Palk Bay, the Andaman and Nicobar Islands and the Lakshadweep.

Genus *Holothuria* Linnaeus, 1764

This is by far the most important genus for processing. Over 100 species are known under this genus.

Key to the species of *Holothuria*

1. Body loaf-like with very thick bodywall.In the living condition about six pairs of lateral teat-like projections are seen, body with black and white patches.....*Holothuria nobilis.*

1'. Body tubular, bodywall not very thick, no lateral projections in the living condition.... 2

2. Body completely black in colour, red colour comes off when handled in the living condition.....*Holothuria atra*

2'. Colour not completely black and no red colourcomes off when live specimens are handled.....3

3. Yellow transverse bands on the dorsal side of the body ; ventral side white with a number black dots.....*H. scabra*

3'. Body uniformly brown in colour small stiff projections all over the body, highly burrowing form.....*H.spinifera*

***Holothuria scabra* Jaeger**

Common name: Sandfish

Local name: Vella attai in Tamil refers to the white colour on the ventral side.

It grows to a length of 450 mm. The body is stout with flattened ends. The dorsal side is convex and the ventral side is flat. It has prominent wrinkles on the dorsal side. The dorsal side is black with white or yellow transverse bands. The ventral side is white with fine black dots. Found in silty sand often near somewhat low saline areas and frequently on *Cymodocea* beds. It spends part of the day buried in the sand with the posterior end always on the surface of the mud. It occurs from the intertidal region upto 10 m depth. Small forms (50 to 90 mm in length) are also seen to be lying freely on the muddy grounds during low tide. At some places there are 2 to 10 specimens distributed in an area of five sq.m. Juveniles are distributed near the shore. As they grow they migrate to deeper waters for breeding. It is gregarious in nature and its density may reach several hundred individuals per hectare. It is the most widely distributed species *Stichopus japonicus*. This is the most extensively processed and also the most expensive species in the world. Processing is slightly complicated due to excessive chalky deposits in the bodywall. After boiling, this species is buried near the shore where the sand is wet to allow the bacteria present in the sand to act on the outer layer of the

skin and make it loose and soft. This product is now thoroughly washed in sea water to remove all the white chalky deposits. A pea crab *Pinnotheres deccanensis* is found to live inside the cloacal chamber of this species. About 10% of this specimens examined were found to have this crab.

The seed of this species was produced for the first time at Tuticorin Research Centre of Central Marine Fisheries Research Institute in 1988 by inducing them to spawn by thermal stimulation. The fecundity is upto one million. The eggs are spherical and just visible to the naked eye. Fertilization is external. Auricularia, doliolaria and pentactula larvae are formed and they settled down on the bottom of the tank at the end of 15 days. The larvae are fed on the microalga *Isochrysis galbana* and the juveniles on the extract of algae like *Sargassum* sp. They grow fast and in two months time they reach a length of 20 mm. when they can be transferred to the sea and grown in concrete rings.

Distribution: It is known from Mascarene Islands, East Africa and Madagascar, Red Sea, South East Arabia, Sri Lanka, Gulf of Mannar and Palk Bay, Andaman and Nicobar Islands, East Indies, North Australia, Philippines, China and Southern Japan and South Pacific Islands.

***Holothuria nobilis* Selenka**

Common name: Teatfish or Mammyfish

Body loaf-shaped with teat-like projections in the live condition inside water. Bodywall 10 to 12 mm in thickness. It reaches a length of 400 mm and live weight varies from 2 to 3 kg. It occurs in two colour forms. It is generally black in colour. Small forms have cream or orange flecks. In the other form the colour ranges from yellowish white to grey-brown. On both the colour forms there is a fine coating of coral sand. Some specialists refer the white form as *H. fuscogilva*. The white and black forms normally occur in different habitats. Black form is more common on shallow reef bottom in the lagoon where there is no wave action. Young forms occur on turtle-grass beds. The white form is more common on coral slabs near reef passages or at the foot of the lagoon side reef slopes. Average density is two animals per hectare. This is high value species. The buyer believes the white forms are true sea cucumbers and therefore they pay more price for them,. Each kg of processed material cost US $ 6.00 to 14.00 depending on colour. Black form is abundant in

some of the lagoons of the Lakshadweep.

Distribution: It is known from the Islands of the Western Indian Ocean, Mascarene Islands, East Africa and Madagascar, Red Sea, Maldives, Lakshadweep, Sri Lanka, Andamans, East Indies, North Australia, Philippines, China and Southern Japan, South Pacific Islands and the Hawaiian Islands. Recently one white form is collected from the Gulf of Mannar.

***Holothuria atra* Jaegar**

Common name: Lollyfish

Local name:Kuchii attai(in Tamil) refers to stick-like shape on processing.

This is the most abundant sea cucumber in the seas around India and elsewhere. Body is cylindrical with a smooth surface. It is uniformly black in colour and reaches a length of 600 mm. When live specimens are handled a red fluid stains the hand. This red fluid is a toxin known as holothurin. Sometimes this species is covered by a fine coat of sand except for circular patches along the sides where papillae are situated. This sand coating takes place if there is fine suspension of sand in the water. It occurs on dead coral reef flats with sandy or muddy patches. It prefers areas where calcareous alga *Halimeda* sp. is abundant as it feeds on it. It usually occurs in 1 to 5 m depth. In some areas 10 to 15 specimens are found in 25 sq.m. area. On the reef flat the length ranges from 200 to 300 mm and on the outer edge of the reef the specimens reach 600 mm in length. Small quantities of this species was processed in the Andamans in 1976 for the first time . In the Gulf of Mannar and Palk Bay this species is processed from 1992. During the year, 28 tonnes was processed. This species spawned several times in the hatchery during the months of August and September but the larvae failed to settle. Since the skin is thin and the value is low this species is not preferred for processing. One kg of processed material costs only one US dollar.

Distribution: This is one of the most widely distributed species in the Indo-Pacific region. It is known from the Islands of the Western Indian Ocean, Mascarene Islands, East Africa and Madagascar, Red Sea, South

East Arabia, Persian Gulf, Maldives, Arabian Sea, Lakshadweep, Sri Lanka, Andaman and Nicobar Islands, East Indies, North Australia, Philippines, China and Southern Japan, South Pacific Islands and Hawaiian Islands. In the seas around India,it is known from the Gulf of Mannar and Palk Bay, the Andaman and Nicobar Islands and the Lakshadweep.

***Holothuria spinifera* Theel**

Common name: Brownfish

Local name:Cheena Attai or *Raja Attai*

Length 250 to 300 mm. Colour uniformly light brown with sharp projections all over the body. The lower side is generally lighter in colour. The papillae project out sharply all over the body, hence the name spinifera . It is never encountered in the intertidal region. They are collected from 12 to 16 m depth. It is found on clean sand. It is highly burrowing form and buries completely into the sand. At Rameswaram there is a good fishery for this species from June to September. They are mostly collected by *Chankumadi* during one day and one night. On an average 20 tonnes of material is landed annually at Rameswaram. This species was once collected for high quality but in recent years this species is not preferred by the buyers. It is processed along with *H.scabra* since the processing method is same. At present it has low market value. One kg of processed material costs US $ 2.0 to 4.0.

Distribution: It is known from the Red sea, Persian Gulf, Gulf of Mannar and Palk Bay, Sri Lanka, North Australia and Philippines. In the seas around India it is known only from the Gulf of Mannar and Palk Bay.

Family : Stichopodidae

Members of this family grow to massive size, some of them reaching a length of nearly one metre. In some the live weight is upto 6 kg. The body is loaf-shaped and in some it is quadrangular. The bodywall is soft and on exposure to air it becomes gelatinous.

Key to the genera of the family stichopodidae

Body massive with numerous large pointed teats in groups on the dorsal side.....*Thelenota*

No pointed teats on the dorsal side, body sometimes quadrangular .....*Stichopus*

Genus *Thelenota* Brandt, 1833

Only one species is known from the Indian seas.

***Thelenota ananas* (Jaeger)**

Common name:Prickly Redfish

This species reaches a length of 700 mm. Thickness of the bodywall varies from 15 to 20 mm, live weight ranges from 1 to 6 kg. Very distinctive appearance because of numerous large pointed teats in groups of two or three all over the body surface. There are numerous large tubefeet on the flat ventral side. Colour in live condition reddish-orange, with the teats darker than the body surface. The tubefeet on the ventral side is bright orange. However the specimens from the Lakshadweep are brown on the dorsal side and bright orange on the ventral side. Distributed on clean sandy bottom at a depth of 2 to 30 m. It is rarely found in the lagoons of Lakshadweep. It feeds on the calcareous alga *Halimeda* sp. Average density is 20 animals per hectare. This is a medium value species. The demand for this common species has grown over recent years. It is now commonly harvested and processed for export to China, attracting quite high prices. Processing similar to teatfish. Bodywall is cut on the ventral side to within 30 mm of each end. One kg of processed material costs US $ 11.50.

Distribution: It is known from Mascarene Island, Lakshadweep, Maldives, East Indies, North Australia, China and SouthernJapan and South Pacific Islands.The record of Tikeder *et al.* (1986) from the Andamans needs confirmation.

Genus *Stichopus* Brandt, 1835

Some of the species belonging to this genus reach a length of 900 mm. Body will disintegrate and becomes gelatinous when taken out of water. Needs special treatment for processing.

Key to the species of *Stichopus*

Body quadrangular with four rows of large finger-likeprocesses. Colour dark green appearing almost black in some shades of light .....*S.chloronotus*.

Body massive and loaf-like with irregular brownpatches on yellow grey background.....*S.variegatus*

***Stichopus chloronotus* Brandt**

Common name: Greenfish

This species reaches a length of 300 mm. The thickness of the bodywall varies from 2 to 6 mm. Live weight varies from 0.2 to 0.4 kg. Body is quadrangular in shape and roughly square in cross section with large prominent papillae at the corner of each square. Body surface is smooth. Tubefeet are arranged in three rows on the ventral side colour very dark green, appearing almost black, the tips of the papillae are orange. It is distributed on reef flats or on broken coral rubble, at depths of 0 to 5 m in areas where there is much water movement. In some of the lagoons of the Lakshadweep it is distributed in large numbers. Average density is several hundred individuals per hectare. This species has medium value. One kg of processed material costs US $ 9.00.

Distribution: It is a widely distributed species. It is known from the Islands of Western Indian Ocean, Mascarene Island, East Africa and Madagascar, Maldives, Lakshadweep, Sri Lanka, Andaman and Nicobar Islands, East Indies, North Australia, Philippines, China and Southern Japan, South Pacific Islands and Hawaii.

***Stichopus variegatus* Semper**

Common name: Curryfish

Localname: Mul Attai (In Tamil) refers to 'spine-like' projections especially in young forms.

It reaches a length of 900 mm and the thickness of the body wall ranges from 10 to 15 mm. Live weight varies from 1 to 6 kg. Body is loaf-shaped, roughly square in cross section. Dorsal surface is convex with rough surface bearing many tubercles. Ventral side flat with many tubefeet. Colour is quite variable. Typically dark yellow with irregular brown patches. Some specimens are almost white or greenish. The tubefeet are pink in colour. Occurs on turtlegrass beds, on sediment or silty sand bottoms to a depth of 30 m. Average density about 50 individuals per hectare. Massive forms occur in deeper

waters in the Andamans. This species has medium to low commercial value. One kg of processed material costs U.S. $ 6.00 to 7.00. Processed like teatfish but should be handled with great care because its bodywall tends to fall apart after harvesting and during boiling.

Distribution: This is also a widely distributed species and is known from Mascarene Islands, East Africa, Madagascar, Red Sea, South Eastern Arabia, Persian Gulf, Maldives, Lakshadweep, Sri Lanka, Gulf of Mannar, Andaman and Nicobar Islands, East Indies, North Australia, Philippines, China and Southern Japan and South Pacific Islands.

Anatomy

Not much information is available on the anatomy of the Indian sea cucumbers. Mary Bai (1978,1980) published on the anatomy and histology of *Holothuria scabra* which is the most commercially important species in the world. James (1967,1968) gave the gross anatomy of the sea cucumbers *Phyllophorus (Phyllophorella) parvipedes* and *Stolus buccalis* respectively. Rao (1968) published the anatomy of the sea cucumber *Psammothuria ganapati* found in the interstitial sands of Visakhapatnam. Mary Bai and Ramanathan (1977) have published the anatomy of the holothurian *Holothuria (Semperothuria) cinrescens* collected from the Kanyakumari coast. Mary Bai (1971) studied the regeneration of the sea cucumber *Holothuria scabra*.

Biology

The biology of *Holothuria scabra* has been worked out by the Central Marine Fisheries Research Institute. It is known to reach a maximum length of 400 mm. It breeds twice in a year in the Gulf of Mannar. The first spawning peak is from March to May and the second during November to December. Size at first maturity for females is estimated at 213 mm and for males it is 210 mm. The fecundity is estimated at 10 lakhs. The longevity is estimated at ten years. At the end of first, second, third, fourth and fifth years it reaches a length of 136 mm, 225 mm 284 mm, 322 mm, and 348 mm respectively. Baskar (1994) published some information on the biology of *Holothuria scabra*. Fish (1967) published an excellent account on the biology of *Cucumaria elongata* from England which should serve as a model for others. Bakus (1973) gave some information on the biology of tropical sea cucumbers. Conand (1990) gave very valuable information on the biology of some commercially important sea cucumbers.

Ecology

Until the advent of the mask and snorkel and the SCUBA diving, very little information was available on the ecology and habits of the sea cucumbers. Most of the papers dealt only with the occurrence of the various species. Nagabhushanam and Rao (1972) published an ecological survey of the marine fauna of the Minicoy Atoll in the Lakshadweep. They dealt with the ecology of 16 species of sea cucumbers. Narasimham *et al.* (1984) estimated the catch of 2270 tonnes of sea cucumber *Acaudina molpadioides* from Kakinada Bay with a range in length from 25 to 160 mm. From their report it is seen to be abundant where salinity is more. The present author has also collected *A. molpadioides* from Ennore backwaters. James (1978b) collected an apodous sea cucumber *Anapta gracilis* from Krishna estuary at Machilipatnam. In the above cases the salinity in the estuary and backwater was high just as in sea. James (1982, 1994) wrote on the ecology and habits of nearly 50 species of sea cucumbers chiefly from the Gulf of Mannar and Palk Bay, the Andaman and Nicobar Islands and the Lakshadweep.

Animal associations

Sea cucumbers show interesting association with other animals, the classic example being that of Carapid fishes with sea cucumbers. Chopra (1932), Jones and Mahadevan (1966) recorded the association of Pea crab *Pinnotheres deccanensis* with the sea cucumber *Holothuria scabra*. Another species of crab *Lissocarcinus orbicularis* is found to live in association among the tentacles of sea cucumber *Actinopyga mauritiana* at Port Blair in the Andamans. Sometimes even two or three specimens are found to live on a single specimen. The tentacular collar is deep like a cup in which the tentacles are situated. This offers excellent protection for the crabs. The crabs were never seen outside and they come out only when the sea cucumber is killed. The crab is brown with white patches and it is well camouflaged on the species of sea cucumber which is brown with white patches. Both males and females were collected. Mukherji(1932) gave an account of the fishes associated with sea cucumbers from the Andamans. Arnold(1953) presented some observations on the habits of Carapid fishes. James (1995) published detailed observations on association of the fish *Encheliophis (Jordanicus) gracilis* from the sea cucumber *Holothuria arenicola* and another species of fish *E. vermicularis* from Port Blair. Jones and Kumaran (1980) have reported two Carapid fishes *Carapus*

parvipinnis and *C. homei* from the sea cucumber *Bohadschia marmorata*. Bakus (1973) also mentioned about this association. James (1978) reported *Pinnotheres* sp. from the sea cucumber *Pseudocolochirus violaceus* from Mandapam. Ganapati and Radhakrishna (1963) recorded a Hesionid polychaete from the sea cucumber *Molpadia* sp. (= *Acaudina molpadioides*) as an instance of inquilinism from Kakinada Bay. Nayar and Mahadevan (1965) reported *Synaptula striata* from the sponge *Petrosia* sp.

Parasites

Being somewhat sluggish the sea cucumbers are subjected to the attack of a number of parasites. Jones and James (1971) have published an account of an internal gastropod parasite belonging to the family Stiliferidae from the cloacal chamber of sea cucumber *Holothuria atra*. Over 1300 specimens of *H. atra* ranging in length from 80 to 350 mm were examined for internal commensals and parasites. Of these 8 were found to harbour gastropods which should be referred to the genus *Megademus* according to Warren (1983). Very rarely *H. scabra* have gall formation on the body. When the body wall of such specimens is cut open a gastropod *Prostilifer* sp. is found deeply embedded in the skin. The presence of the gastropod is indicated by the apex of the shell which slightly projects out. When touched it withdraws into the gall. Though thousands of *H. scabra* were examined during the last 30 years, only on a few occasions were such galls noticed. Normally the bodywall of *H. scabra* is 10 to 15 mm in thickness. As a result of infestation the skin becomes very thick due to gall formation. The parasite is firmly entrenched in the bodywall. *Prostilifer* is also known from the sea cucumber *Bohadschia argus* (Dr. Anders Warren: personal communication). Though hundreds of *B. argus* were examined at Lakshadweep no gastropod was found in this species, there.

Distribution and zoogeography

The study of zoogeography of sea cucumbers owing to their relatively sedentary life, their aversion to fresh or even brackish water, the brevity of the larval life and usually small bathymetrical range is interesting. Bell (1887) wrote on the zoogeography of echinoderms. James (1971) mentioned the distributional pattern of the echinoderms of the Indian Ocean. Rao (1980) described the zoogeography of the interstitial forms like *Trochodota havelockensis* and *Leptosynapta* sp. from the Andamans. James (1986) published a detailed paper on the zoogeography of the shallow water echinoderms of the Indian

seas. He noted that despite the close proximity of India to Sri Lanka there is marked difference in the species composition of the echinoderms along the respective coasts. This distributional pattern is rather difficult to explain since most of the sea cucumbers have a wide range of distribution in the Indo-Pacific region. This difference in distribution could be due to the role played by the currents and is indicative of the presence of a barrier which does not favour the movements of sea cucumbers from Sri Lanka to the Indian side. Another important factor is the 'Area effect' referred to by Price (1982). The Sri Lankan coast is far more extensive than the coastline of the Gulf of Mannar and Palk Bay on the Indian side. Therefore a corresponding increase in species diversity is apparent.

Biotoxicity

One of the defensive mechanisms for the sea cucumbers is the presence of toxins in the body to ward off predators from attacking them and also the fouling organisms from settling on them. These toxins have anti-tumorous, anti-cancerous and anti-fertility properties. When *H. atra* is handled in the live condition a red-coloured material comes out. This is the toxin known as holothurin. James (1986b) conducted experiments using this toxin at Port Blair and at Mandapam to eradicate undesirable organisms from the farms. Rao *et al.* (1985a,1985b) gave a detailed account of the toxicity of *H. spinifera H. scabra, H. atra* and *B.marmorata. Holothuria atra* and *B.marmorata* exhibited a high degree of toxicity to fish fingerlings and mice and also showed strong action on rabbit erythrocytes. Much work remains to be done in this line from India.

Processing

In the phylum Echinodermta only the ripe gonads of some species of sea urchins and processed bodywalls of some species of sea cucumber are of economic importance. Processed sea cucumbers are a delicacy for the Chinese. *Stichopus japonicus* is consumed in the raw condition by the Japanese and the Koreans. Sea cucumber processing was introduced by the Chinese more than one thousand years back into India. In olden days pearls and processed sea cucumbers were sent from India in exchange for silk and porcelain. The processed material or *beche-de-mer* is actually the boiled and dried skin. The processing chiefly consists of three steps *viz.*, degutting, boiling and drying. In some species like *H. scabra, H. spinifera* and *B.marmorata* where there is

an excess of spicules in the bodywall, they have to be buried after boiling, in wet sand near the shore so that the bacteria in the sand can act on the outer layer of the skin to make it soft for easy removal of spicules during washing.

Collection of sea cucumbers

Sea cucumbers for processing are chiefly collected by skin diving. The divers go in the morning in sail boats and return with the catch in the afternoon. They use aluminium plates for the feet in the place of flippers. In some places like Mandapam, the entire material for processing comes from trawlers. Some material also comes from *Thallu Madi*. Fortunately collection by SCUBA for sea cucumbers is not done in India.

Handling of sea cucumbers

Sea cucumbers, being soft-bodied animals have to be handled with care after collection since the value of the product depends on the shape. They should not be exposed to the sun after collection since the top surface dries up and peels off. Species of *Stichopus* should never be exposed to air for long since the bodywall becomes gelatinous rendering them unfit for processing.

First Cleaning

The sea cucumbers are cleaned in seawater to remove dried slime, sand and other extraneous particles and left-over gut and other entrails. While cleaning it is desirable to squeeze the sea cucumbers to remove the water that the animal would have consumed during storage.

Degutting

For species like *Holothuria scabra, H. spinifera* and *B.marmorata* a slit of 20 to 30 mm is made at the posterior end with a sharp knife. Immediately the intestines, gonads and respiratory trees spill out of the slit. In case of *Holothuria atra* when it is very long it is cut at both the ends to remove all the internal organs. For species of *Actinopyga* no degutting is necessary. During boiling all the internal organs come out. In case of *Holothuria nobilis* where the skin is very thick, a cut is made on the dorsal side in the middle leaving 30 mm at each end. The internal organs still left in the body are removed and cleaned in seawater. In case of *Thelenota ananas* the slit is made on the ventral side leaving 30 mm on each side.

Boiling

Boiling is a very important step in processing the sea cucumbers since the quality of the final product depends on the shape of the vessels used and the stirring done during the boiling. Sea cucumbers are always boiled in seawater for about an hour depending on the size of the specimens. A distinct cooked odour comes out at the end of boiling. The material can also be subjected to bouncing test to find out whether the boiling is sufficient or not. When the boiled sea cucumbers are dropped on hard surface like a rock they bounce like a rubber ball. Usually boiling is done in 200 l oil drums. They are sealed at both the ends and cut on the horizontal plane. Since it is made of iron it easily gets rusted and also this type of oil drum does not allow much stirring. During boiling the material should be allowed to roll due to stirring. For best results the material should be boiled in flat saucer-shaped cast iron pans which will allow rolling during stirring.

Burying

As stated earlier burying is done only for some species where too much of calcareous material is present in the outer layer of the skin. Usually boiling is over in the evening. First a pit is dug near the shore where the sand is moist. A gunny bag lining is given in the pit and the boiled material is put into that. Then the material is covered by a gunny bag and finally covered by moist sand. The bacteria in the sand act on the outer layer of the skin loosens all the calcareous material. The boiled material is kept for 15 to 18 hours for the bacteria to act on the outer layer of the skin. If the material is kept inside the pit for too long the inner flesh will be eaten away by the bacteria leaving ugly pits on the surface rendering the material useless for export.

Second Cleaning

After 15 to 18 hours the sea cucumbers are removed from the pit and put into palm-fibre woven baskets. By now the bacteria would have acted on the outer layer of the bodywall. This makes the bodywall soft. Then the material is thoroughly scrubbed and cleaned with fresh seawater. Material which is free from white material sticking to it is once again boiled in seawater for five minutes to kill the bacteria sticking to them.

Drying

Drying is one of the most important operations in the processing of sea cucumbers (Pl.II, C & D). Sun drying is the best when compared to smoke drying. When the sun is good it takes five or six days for complete drying. They should not be bone dried. Usually 8 to 10% moisture content is advisable. The material should never be put directly on sand or on rocks since sand particles and other dirt will stick to the material. *Beche-de-mer* is a hygroscopic material. During rainy season it absorbs water. Therefore the material has to be packed in polythene sheets.

Conservation and management

Since sea cucumbers do not offer any resistance at the time of capture and also do not make any attempts to escape from the captors they are quickly overexploited from any particular region. Sea cucumber processing was introduced in the Maldives in 1986 with a modest harvest of 2 tonnes. This figure shot up to 800 tonnes in 1990 as a result of overexploitation. Added to the overexploitation problem, the sea cucumbers are slow growing animals. They take two years to reach full length. Despite these drawbacks, the fishery is able to survive and sustain, though on a low scale, due to their high fecundity, cryptic habits, low value which will not allow all the specimens to be collected. Fortunately, the spawning populations are beyond the reach of the ordinary divers and SCUBA is also not used in the collection of sea cucumbers in this country. Several countries have banned the use of SCUBA.

James and James (1994b, 1994c) wrote on the conservation and management of sea cucumbers. In 1995, the Lakshadweep Administration issued 10 conservation methods based on the report of the author to the Lakshadweep Administration. Some of the conservation and management methods are listed below.

Size regulation: Size regulation is the most important measure for conservation. Sea cucumber shrink by 42% on processing (Baskar and James, 1989). Export of *Beche-de-mer* samples below 75 mm length was banned by the Government of India in 1982. This covers animals 250 mm in the live condition. This ban is still in force. The size at first maturity in the case of *H. scabra* is estimated at 230 mm (Baskar, 1994). Therefore it is advisable to return all the specimens below 250 mm to the sea. Sea cucumbers live out of

water for a long time. Therefore undersized sea cucumbers collected can be returned to the sea, for further growth. It is better to leave them on the beds from where they were collected rather than bringing them to the shore and throwing them into the sea. While there is ban on the export of material less than 75 mm in length, there is no ban on the catching of juveniles. Lakshadweep Administration banned the collection of *H.nobilis* below 150 mm length.

Closed seasons: Sea cucumbers should not be fished round the year for processing. There should be closed seasons during the breeding period allowing the animals to spawn. *Holothuria scabra* breeds in the Gulf of Mannar twice. There is a major peak during March to April and minor peak during November to December. Unfortunately, the peak season for diving in the Gulf of Mannar is during January to April since the sea is calm and visibility is good.

Extension of the area of collection: In the seas around India sea cucumbers of commercial value are found in the Gulf of Mannar and Palk Bay, the Andaman and Nicobar Islands and the Lakshadweep. Intense fishing and processing is going on only in the Gulf of Mannar and Palk Bay. Even in this region, only at particular places the diving is taking place. Between Kilakarai and south of Tuticorin for a stretch of over 100 km there is no diving for sea cucumbers. Unfortunately, collection and processing of sea cucumbers is banned in the Andaman and Nicobar Islands. The processors should be allowed to collect this valuable resource subject to some conservation measures. In the Lakshadweep also, there was no processing till 1994. It was overexploited by some party from Bombay in 1994 leading to the destruction of the natural populations. From 1995 onwards, the fishery is being regulated based on the recommendations suggested by the author. The Gulf of Kutch and surrounding areas also should be surveyed for this resource. *Holothuria scabra* has been reported from the Malwan coast by Parulekar (1981). This record needs confirmation.

Processing of other species: Surprisingly, till 1989 only three species *viz., Holothuria scabra, H. spinifera* and *Bohadschia marmorata* were processed from the Gulf of Mannar and Palk Bay, even though other valuable species were available. The Chinese when they introduced the processing nearly one thousand years ago, confined it to these three species only. Of these, *Holothuria scabra* formed 90% putting lot of pressure on this species. In 1989,

A. echinites, in 1990, *A. miliaris* and in 1991, *Holothuria atra* were introduced for processing from the Gulf of Mannar. From 1994 onwards, *Holothuria nobilis*, *Thelenota ananas*, *Actinopyga mauritiana* and *Stichopus chloronotus* are processed from the Lakshadweep. The processing of other species release pressure on the target species.

Need for biological information to regulate exploitation: For the management of the sea cucumber fishery, information on catch and effort, weight of the specimens (correct length measurements cannot be taken in case of sea cucumbers because of constant expansion and contraction), breeding season and fecundity has to be recorded for each species. Estimates on the age and growth have to be made. Even though several species form the fishery in several parts of the world, the above information is sadly missing. In the absence of the above data it is not possible to estimate the stocks and calculate the maximum sustainable yield. Baskar (1994) gave some details on the biology of *Holothuria scabra* from the Gulf of Mannar. Kandan (unpublilshed) collected information on the biology *Holothuria nobilis* and *Actinopyga mauritiana* from the Minicoy Island in the Lakshadweep. Conand (1998) gave some information on the biology of commercially important species from the New Caledonia. Clearly more information needs to be collected on a continuing basis for all the species that are now processed from India and elsewhere.

Closed areas It is well known that certain areas are breeding grounds for the sea cucumbers and also in certain areas juveniles are found in large numbers. Collection in such areas should be totally banned. Normally inshore areas have more juveniles than offshore areas. Also, in the slightly less saline areas more juveniles are found since they are able to tolerate wide range in salinity. In Port Blair (Andamans) in 1977 a bed of juveniles of *H. scabra* was located near the South Point. Such areas should be protected from collectors.

Development of organized Beche-de-mer industry: Unfortunately the *beche-de-mer* industry is not an organized industry. *Beche-de-mer* processing factories can be opened on the Gulf of Mannar and Palk Bay. Hornell (1917) mentioned about a Government Factory in Tirupalakudi with economics worked out. He suggested that another factory can be opened at Vedalai. In Sri Lanka, a *beche-de-mer* factory was opened at Mannar in 1974 under a fisheries co-operative society. Paramanandan (1974) has given the advantages of processing *beche-de-mer* in a factory and has also given the cost analysis. He has

also clearly shown that in order to run the factory successfully they have to process atleast 1.2 tonnes *beche-de-mer* per month. The processing by selected and trained staff to ensure uniformity, hygienic conditions, greater care for better standard and quicker production are primary requisites for the success of the industry. Bad weather conditions will not affect processing, individual suppliers of raw material will find continuous employment. In this, a society can afford to expand and improve the quality of *beche-de-mer*. It is worth making an effort under the co-operative sector by opening one or two factories along the Gulf of Mannar and Palk Bay. The *beche-de-mer* industry can thus be managed in a better and organised manner.

Hatchery and culture

The Japanese are pioneers in the production of seed of *Stichopus japonicus*. Inaba (1937) induced them to spawn by thermal stimulation. Recently seed of *Actinopyga echinites* was produced by Chen and Chian (1990) from Taiwan. Although the sea cucumber *Holothuria scabra* yields high grade *beche-de-mer* and forms a fishery in several parts of the world, it is surprising that the seed of this valuable species was not produced earlier. James *et al.* (1989) produced the seed of *H. scabra* for the first time at the TRC of CMFRI, Tuticorin by inducing them to spawn by thermal stimulation. Since then, the seed of this species has been produced on a number of occasions. James (1993, 1994a, 1994b, 1996a, 1996b,1997), James and James (1993), James *et al.* (1994a, 1994b) gave details of the hatchery and culture of the sea cucumber *Holothuria scabra*.

James (1996c) described the farming methods. James *et al.* (1996) gave the results of rearing of the juveniles of *H. scabra* produced in the hatchery.

Acknowledgement

I thank Dr. M. Devaraj, Director, Central Marine Fisheries Research Institute, Kochi-14 for his kind interest and encouragement.

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